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MODEL TEST AND SEEPAGE ANALYSIS ON CLAYEY GROUND CONFINING SAND LAYERS

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1. INTRODUCTION

In case of large-scale land reclamation, it is important to predict the long-term ground settlement induced by soil consolidation. Appropriate prediction enables the proper maintenance of facilities on reclaimed land. For instance, Kansai International Airport in Japan, where the overburden pressure of reclamation reached 539 kN/m^2, is expected to subside over a few decades, and a long-term maintenance plan for airport facilities such as runways and terminal buildings is needed.

Clayey ground often confines sand layers, e.g., at the construction site of Kansai International Airport. At such sites, excess pore water pressure induced by the overburden pressure of reclamation spreads to the surrounding areas through sand layers, and this phenomenon affects the trend of consolidation settlement. Details of the effect of sand layers have been unclear to date. Therefore, in this study, a model test was carried out to investigate the consolidation behaviour of clayey ground confining sand layers, and seepage analysis was performed to simulate the dissipation behaviour of excess pore water pressure.

The Cam-Clay model is usually applied to simulate consolidation settlement in geotechnical engineering. In this model, constant stiffness is applied to each element of normally consolidated and over-consolidated soil. This indicates that the model does not consider extremely high stiffness of the surrounding clayey ground in the state of a bit of swelling due to excess pore water pressure from sand layers. This study shows that seepage analysis appropriately simulates the test result by considering high stiffness in the state of swelling.

2. MODEL TEST

Figure 1 shows the cross-sectional view of a tested model. The clay ground was created using Kaolin clay, and the ground confined two 20 mm-thick sand layers. The solid circles in the figure represent the positions of pore water pressure gauges. First, the clay ground was pre-consolidated with an overburden pressure of 98 kN/m^2. Then, the loading plate was equally divided into three parts, and the pressure level of all three plates was set to 30 kN/m^2. After confirming complete consolidation, the pressure by the left-hand side plate was increased to 70 kN/m^2. This means that only a third of the left-

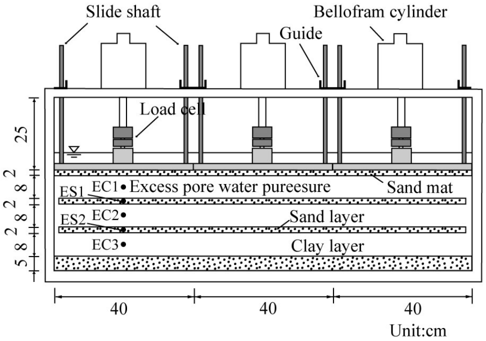


Fig. 1 Cross-sectional view of model

hand side area was loaded with an additional overburden pressure of 40 kN/m^2. Finally, ground settlement and excess pore water pressure were measured during the consolidation.

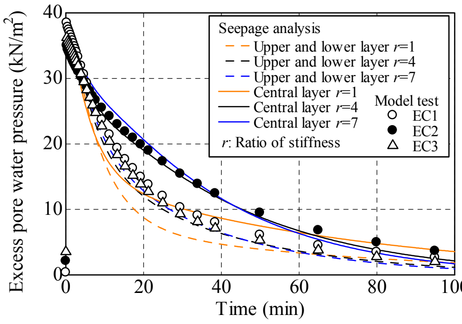
3. SEEPAGE ANALYSIS

The fundamental equation of seepage analysis can be written as follows.

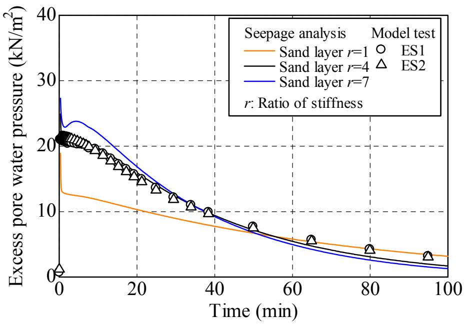
$$S_s \frac{\partial \varphi}{\partial t} = \frac{\partial}{\partial x}\left(k\frac{\partial \varphi}{\partial x}\right) + \frac{\partial}{\partial y}\left(k\frac{\partial \varphi}{\partial y}\right)$$

Here, S_s stands for specific storage, φ indicates pressure head, and k is the permeability coefficient. This equation is derived by applying Darcy's law to the continuous equation, assuming a constant density of water, isotropy of permeability, and full saturation of ground. The implicit-finite difference method was applied to discretize the equation. The permeability coefficients of clay and sand were 0.01 cm/s and 4.0 × 10^{-7} cm/s, respectively, and their specific storages were 7.0 × 10^{-4} l/cm and 2.8 × 10^{-2} 1/cm, respectively. The high stiffness in the state of swelling was taken into consideration by lessening the specific storage.

The time histories of excess pore water pressure, in both the clay and the sand layers, are shown in Fig. 2. This figure shows the excess pore water pressure measured in the model test and calculated by seepage analysis. In seepage analysis, the ratio between stiffness of compression and swelling, r, was successively set to 1, 4, and 7. On comparing the results of the model test and the seepage analysis, the excess pore water pressure obtained in seepage analysis, at r = 1, was lesser than that found in the model test, in both the clay and the sand layers. At r = 4, the pressure obtained in both the cases was the same. In case of r = 7, however, the pressure obtained in seepage analysis was larger than that found in the model test in the sand layer. These results show that the proper consideration of high stiffness in the state of swelling enables a seepage analysis to simulate the dissipation behaviour of excess pore water pressure in clayey ground confining sand layers.



(a) Clay layer



(b) Sand layer

Fig. 2 Excess pore water pressure

4. CONCLUSION

In this study, the model test and the seepage analysis for clay ground confining sand layers were conducted. The results showed that considering high stiffness in the state of swelling in seepage analysis enabled accurate simulation in clayey ground confining sand layers.

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